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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
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08/995,108 12/19/97 DING P AM-1776

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EXAMINER

MERCADO, J

ART UNIT

PAPER NUMBER

1753

DATE MAILED: 09/02/99

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Office Action Summary

Application No.
08/995,108

Applicant(s)
Ding et al.

Examiner
Julian A Mercado

Group Art Unit
1753



☐ Responsive to communication(s) filed on _____

☐ This action is **FINAL**.

☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire 3 month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☒ Claim(s) 1-27 is/are pending in the application.

Of the above, claim(s) 1-7 is/are withdrawn from consideration.

☐ Claim(s) _____ is/are allowed.

☒ Claim(s) 8-27 is/are rejected.

☐ Claim(s) _____ is/are objected to.

☒ Claims 1-27 are subject to restriction or election requirement.

Application Papers

☒ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on _____ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on _____ is ☐ approved ☐ disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been
☐ received.

☐ received in Application No. (Series Code/Serial Number) _____

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: _____

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☒ Notice of References Cited, PTO-892

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). 2

☐ Interview Summary, PTO-413

☒ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

--- SEE OFFICE ACTION ON THE FOLLOWING PAGES ---

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DETAILED ACTION

Election/Restriction

1. Restriction to one of the following inventions is required under 35 U.S.C. 121:

- I. Claims 1-7, drawn to the product, classified in class 428, subclass 627.
- II. Claims 8-27, drawn to the method, classified in class 204, subclass 192.1.

The inventions are distinct, each from the other because of the following reasons:

Inventions I and II are related as process of making and product made. The inventions are distinct if either or both of the following can be shown: (1) that the process as claimed can be used to make other and materially different product or (2) that the product as claimed can be made by another and materially different process (MPEP § 806.05(f)). In the instant case the barrier layer of invention I can be made by other processes such as plating.

Because these inventions are distinct for the reasons given above and the search required for Group I is not required for Group II, restriction for examination purposes as indicated is proper.

During a telephone conversation between Jason Resnick (A.U. 1775) and Sheryl Church on August 5, 1999, a provisional election was made without traverse to prosecute the invention of Group II, claims 8-27. Affirmation of this election must be made by applicant in replying to this Office action. Claims 1-7 are withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

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Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a petition under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

Claim Rejections - 35 USC § 112

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claims 21-27 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

Claims 21, 23 and 27 recite a Cu {111} crystallographic content of at least 70%. It is unclear how Applicant has determined the instant range of crystallographic content. The specification appears to be lacking support for the instant range. Figure 2 of the Application also appears to be silent in either clearly teaching the instant range or suggesting such a range from interpretation of the graph.

Clarification is requested in response to this Office Action.

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Claims 22 and 24-26 are rejected under 35 U.S.C. 112, first paragraph, as being dependent upon a rejected base claim.

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. Claims 21-27 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

The scope of claims 21-27 include "the barrier layer of claim 1". Claim 1 has been withdrawn from further consideration in this Office Action, in response to Applicant's election to prosecute claims 8-27 (see attached Election/Restriction). The scope of claims 21-27 are therefore indefinite.

Claims 21 and 23 recite the limitation "the barrier layer of claim 1" in line 1 of each claim. There is insufficient antecedent basis for this limitation in the claim, since claim 1 has been canceled.

Claims 22 and 24-27 are rejected under 35 U.S.C. 112, second paragraph, as being dependent upon a rejected base claim.

Claim Rejections - 35 USC § 102

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6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless --

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

7. Claims 8-11, 14, 15 and 17 are rejected under 35 U.S.C. 102(b) as being anticipated by Colgan (U.S. Pat. 5,281,485).

At the outset, it is noted that the preamble recitation of a barrier layer useful in combination with a conductive layer was not given the effect of a limitation in the claim. The preamble appears to be only directed to the purpose or intended use of the barrier layer, and the additional components of the claim(s) can stand alone without depending on the preamble for completeness.

now requires conductive layer
Colgan teaches sputter depositing a first layer of TaN and a second layer of Ta. The respective layers are deposited within the instant thickness ranges. (Col. 5 lines 54-60) It is considered that TaN, because it is formed via nitridation of elemental Ta, will range for TaN_x wherein x is from 0.1 to about 1.5. The substrate is not heated, although a disclosure is made of a prior art heating step. (Col. 6 lines 39-40) It is considered that the substrate therefore is within the instant substrate temperature from about 25°C to about 500°C.

Claim Rejections - 35 USC § 103

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8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

9. Claims 8-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gelatos *et al* (U.S. Pat. 5,391,517) in combination with Landers *et al* (U.S. pat. 5,676,587)

Gelatos teaches a method of producing barrier layer for the subsequent deposition of an overlaying conductive layer. In reference to Figure 3, a first layer of TiN_x [18] is deposited followed by a second layer of Ti [20]. (Col. 3 lines 39-60) It is reasonably presumed that TiN_x is 1:1 stoichiometric, i.e. TiN_x wherein x is about 1.0, since the TiN_x layer formed via a sputtering method. The first and second layers comprise a barrier layer for the overlaying copper conductive layer [24]. (Col. 4 lines 30-38) Note that the respective thickness of each layer in the barrier layer structure is within the instant thickness ranges. (Col. 3 line 61 to col. 4 line 5)

The difference between the claimed invention and Gelatos not yet discussed is barrier layer comprising a first layer of TaN and a second layer of Ta.

Landers specifically teaches that in the art of integrated circuit manufacturing, both Ti/TiN layers and Ta/TaN layers are well known, and such barrier layers are formed in combination with the subsequent deposition of an overlaying conductive layer such as copper. (Col. 1 lines 30-57) Note that Landers's discussion of both Ti/TiN layers and Ta/TaN layers is a prior art, i.e.

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background art discussion, while the Ti/TiN and Ta/TaN layers is within the scope of the invention. (claim 3)

In Gelatos' invention, the first layer of TiN_x followed by the second layer of Ti allows for improved adhesion of the copper layer onto the Ti layer. In addition, the copper layer is prevented by the TiN_x/Ti interface from diffusing into underlying layers, thereby enhancing device performance. (Col. 2 lines 1-14)

The examiner notes that for the purposes of describing the duality of the barrier layer as evidenced by the prior art, the convention of first layer/second layer has been followed, e.g. TiN_x/Ti as discussed above. This convention was chosen to most clearly address the materiability of the prior art with Applicant's invention, as recited by Applicant in the present claims. While in Landers a disclosure is made of a Ta/TaN layer, the figures illustrate the Ta/TaN layer as one layer [12], making any interpretation of the relative layering of Ta and TaN unclear. It is emphasized, however, that for the purposes of establishing as obvious prima facie Gelatos in view of Landers, the examiner relies on Landers solely to render obvious at least to one skilled in the art that tantalum and titanium metals are well-known equivalents as refractory metals for barrier layer formation. A more pertinent teaching of Landers is that the combination of a refractory metal and its respective nitride is well-known, for reasons such as prevention of diffusion and electromigration. A refractory metal/metal nitride layer combination as a barrier layer is evidenced by Gelatos as well, as discussed above.

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Regarding the instant substrate temperature, it is considered that at least at the outset of sputtering the layers of the barrier structure, the substrate temperature is reasonably presumed to be 25°C, e.g. room temperature, and that the end range of 500° C is inherently present in sputtering due to ohmic heating of the wafer as well as heating from the harsh environment of the sputtering plasma.

A TaN_x layer wherein x ranges from about 0.1 to about 1.5 is considered an obvious range, since a stoichiometric amount of TaN would have Ta and N present at a 1:1 ratio, e.g. wherein x equals 1.0.

At the time the invention was made, it would have therefore been obvious to one of ordinary skill in the art to modify Gelatos' invention by employing a first layer of TaN_x and a second layer of Ta, e.g. substituting a tantalum and/or tantalum nitride target in the film formation steps, because tantalum is a well-known metal in barrier layer formation as evidenced by Landers, and use of either metal would have been an obvious matter of choice to one of ordinary skill in the art when considering device performance or compatability of the underlying refractory metal layers with the final wiring layer.

In view of the foregoing discussion, the difference between the claimed invention and Landers is the Ta/TaN barrier layer deposited as a first layer of TaN followed by a second layer of Ta.

It is considered that it would have also been obvious to one of ordinary skill in the art to modify Landers invention by employing the disclosed Ta/TaN layer such that a first layer is TaN

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and a second overlaying layer is Ta. As discussed above, Gelatos teaches that such a barrier or interface layer, wherein a metal nitride is deposited as a first layer followed by the overlaying deposition of the elemental metal, provides for improved adhesion of copper in the formation of an interconnect structure. (Col. 1 lines 65-68)

10. Claims 8-17 and 21-26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hoshino (U.S. Pat. 4,985,750) in view of Landers.

Hoshino teaches a method of producing barrier layer for the subsequent deposition of an overlaying conductive layer. In reference to Figure 2, a first layer [20] of the barrier layer is deposited by a traditional sputtering method followed by the deposition of a second layer [22], the second layer being a Ta layer having a thickness in the range of 500 to 3000 Å. A conductive layer of copper [24] is then deposited over the barrier layer. (Col. 3 lines 28-66) The copper (Cu) layer is also deposited by a physical vapor deposition technique such as sputtering, then annealed at a temperature of less than 500 °C. (Col. 4 lines 3-13 and 38-40)

The difference between the claimed invention and Hoshino not yet discussed is the first layer of the barrier comprising the instant TaN layer, the Cu crystallographic content being at least 70% of the Cu {111} crystallographic content and a substrate temperature of less than about 500 °C.

All is applied for Landers as discussed above.

Landers as discussed above teaches a Ta/TaN layer. As discussed above, it was unclear from the disclosure of Landers if the Ta/TaN layer comprised the deposition of a first layer of

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TaN followed by a second layer of Ta, or the Ta/TaN layers deposited in reverse order. Hoshino, however, specifically teaches that it is desired to have a *second* layer [emphasis added] of Ta prior to the deposition overlay of a copper layer. The Ta layer prevents the reaction and interdiffusion of the copper layer with the underlaying layers. (Col. 3 lines 49-56)

Regarding the instant Cu crystallographic content being at least 70% of the Cu {111} crystallographic content, it is considered that the copper layer as taught by Hoshino has at least 70% of the Cu {111} crystallographic content, since in Hoshino's invention the copper layer is overlaid onto a tantalum layer ranging from 500 angstroms to 3000 angstroms. As set forth in claims 21 and 23, a copper layer having at least 70% of the Cu {111} crystallographic content can be obtained by depositing the copper layer using a pure Ta barrier layer which is about 500 Å thick. Since in Hoshino's invention the copper is deposited onto a Ta layer ranging from 500 to 3000 Å, it is reasonably presumed that the copper layer is the instant at least 70% of the Cu {111} crystallographic content.

It is considered that a substrate temperature of less than about 500° C is inherently present in sputtering due to ohmic heating of the wafer as well as heating from the harsh environment of the sputtering plasma. As discussed above, both Hoshino and Landers teach sputtering in the formation of interconnect structures.

Hoshino in view of Landers as discussed in the foregoing disclose the claimed invention, or render as obvious modifications to one skilled in the art, except for the deposition of the copper layer at a temperature of less than about 300°C. It would have been obvious to one of

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ordinary skill in the art to deposit copper at such a temperature range, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

At the time the invention was made, it would have been obvious to one of ordinary skill in the art to modify Hoshino's invention by employing a first layer of TaN, because Landers teaches that a TaN layer/Ta layer combination is well known in the art in the manufacture of copper interconnect structures, and that such a layer is effective in the prevention of diffusion and electromigration

11. Claims 8-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hindman *et al* (U.S. Pat. 5,240,880) in view of either Landers *et al* or Hoshino.

In reference to Figure 2, Hindman teaches a method of producing barrier layer for the subsequent deposition of an overlaying conductive layer. A first layer of TiN [54] is deposited followed by a second layer of Ti [60]. Note that the respective layers are within the instant thickness ranges. (Col. 4 lines 9-13) The conductive layer is aluminum. Hindman teaches that the second layer of Ti is performed so as to clean off local nitrides from the titanium sputtering target. (Col. 4 lines 66-68) The titanium nitride layer is formed in the presence of a reactive nitriding gas plasma; the reaction of this gas with elemental titanium is considered to result in TiN_x wherein x ranges from about 0.1 to about 1.5.

Hindman teaches that during the deposition steps, the substrate temperature is maintained in accordance with either a cold deposition or hot deposition. Note that the substrate temperature

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is within the instant range of 25°C to 500°C. It is further considered that at least at the outset of sputtering the layers of the barrier structure, the substrate temperature is reasonably presumed to be 25°C, e.g. room temperature, and that the end range of 500° C is inherently present in sputtering due to ohmic heating of the wafer as well as heating from the harsh environment of the sputtering plasma.

The difference between the claimed invention and Hindman not yet discussed is the barrier layer comprising TaN and Ta, and the conductive layer being copper.

All is applied for Landers and Hoshino as discussed above.

Landers and Hoshino are relied upon to show that the current state of the art teaches the skilled artisan the use of copper as a replacement for aluminum in the formation of metal lines. Landers and Hoshino, as discussed above, are considered to render as an obvious matter of choice to one skilled in the art the use of Ta as the barrier metal.

At the time the invention was made, it would have been obvious to one of ordinary skill in the art to modify Hindman's invention by employing copper as the conductive layer, and tantalum and tantalum nitride as the barrier layer, because either Landers or Hoshino teach that these metals are well-known in the formation of interconnect structures, and it is considered that one skilled in the art would have found obvious the use of copper, tantalum and tantalum nitride in order to improve device performance.

12. Claims 12, 13, and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Colgan *et al* in view of either Landers *et al*, Gelatos *et al* or Hoshino.

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All is applied for Colgan as discussed above.

The difference between the claimed invention and Colgan not yet discussed is the TaN/Ta layer used as a barrier layer in combination with a conductive layer.

Landers, Gelatos and Hoshino are relied upon to show a barrier layer such as TaN/Ta used in combination with a conductive layer such as the instant copper.

At the time the invention was made, it would have been obvious to one of ordinary skill in the art to modify Colgan's invention by employing the barrier layers in combination with a conductive layer, because either Landers, Gelatos or Hoshino teach that such barrier layer/conductive layer combinations are well-known in the formation of semiconductor devices, and that such devices are the current state-of-the-art in having improved electromigration and layer diffusion resistance.

13. Claims 18-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gelatos *et al* in combination with Landers *et al* as applied to claims 8-17 above, and further in view of Ngan (U.S. Pat. 5,707,498).

14. Claims 18-20 and 27 are also rejected under 35 U.S.C. 103(a) as being unpatentable over Hoshino in view of Landers as applied to claims 8-17 above, and further in view of Ngan.

15. Claims 18-20 are also rejected under 35 U.S.C. 103(a) as being unpatentable over Colgan *et al* in view of either Landers *et al*, Gelatos *et al* or Hoshino as applied to claims 12, 13, and 16 above, and further in view of Ngan.

All is applied for Gelatos, Landers, Hoshino and Colgan as discussed above.

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The difference between the claimed invention and Gelatos, Landers, Hoshino and Colgan is at least a portion of the Ta layer and TaN_x layer deposited using ion-deposition sputtering.

Gelatos, Landers, Hoshino and Colgan as discussed above teach traditional sputtering. Ngan teaches that in the manufacture of semiconductor devices, ion-deposition sputtering is preferred over traditional sputtering in order to have uniform step coverage and filling of contact hole vias. (Col. 1 lines 44-56) Note that Ngan uses ion-deposition sputtering to deposit an elemental metal and its corresponding nitride *such as* titanium and titanium nitride. (Col. 7 lines 43-66) It is considered that Ngan's teaching of titanium and titanium nitride is merely illustrative and not restrictive. As discussed above, the use of tantalum (or any other refractory metal, for that matter) is considered to be well-known and obvious at least to one skilled in the art.

At the time the invention was made, it would have been obvious to one of ordinary skill in the art to further modify either Gelatos, Landers, Hoshino or Colgan by employing ion-deposition sputtering, because Ngan teaches that ion-deposition sputtering improves deposition in semiconductor manufacturing.

Conclusion

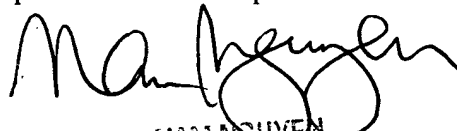
16. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. U.S. Patent 5,521,120 to Nulman *et al*, U.S. Patent 5,571,752 to Chen *et al* and U.S. Patent 5,795,796 to Kim are cited of general interest.

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Any inquiry concerning this communication or earlier communications from the examiner should be directed to Julian A. Mercado whose telephone number is (703) 305-0511 . The examiner can normally be reached on Monday through Thursday from 8:30 AM to 6:00 PM. The examiner can also be reached on alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam X. Nguyen, can be reached on (703) 308-3322. The fax phone number for the organization where this application or proceeding is assigned is (703) 305-7718.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.


NAM NGUYEN
PRIMARY EXAMINER
GROUP 1100

jam/August 30, 1999

